

### Molar Volume, Density, and Molar Mass Determinations from STP

How many liters does 2.34 mol of butane occupy at STP?

How many mol of oxygen do you have if you have 130ml of oxygen at STP?

How many grams of carbon dioxide do you have if you have  $2.4 \times 10^4$  ml of it at STP?

What is the density of  $\text{NH}_3$  at STP in g/L?

What is the density of  $\text{C}_4\text{H}_{10}$  at STP in g/L?

What is the molar mass of a gas with a density of 2.59 g/L? Is this gas propane or butane? (molar masses are 44.1 and 58.1 g/mol, respectively)

A 1.25 g sample of the gaseous product of a chemical reaction was found to have a volume of 350. ml at  $20.0^\circ\text{C}$  and 750. mm Hg. What is the molar mass of this gas? (Hint remember the gas laws)

# The Ideal Gas Law

## Section Review 12.2

**DIRECTIONS:** Write on the line at the right of each statement the letter preceding the word or expression that best completes the statement.

1. Common units for the gas constant  $R$  are (a)  $\text{L} \cdot \text{atm}$ ; (b)  $\text{mol} \cdot \text{K}$ ; (c)  $(\text{L} \cdot \text{atm})/(\text{mol} \cdot \text{K})$ ; (d)  $\text{atm}/\text{K}$ . \_\_\_\_\_ 1
2. The ideal gas law combines Boyle's law, Charles' law, and (a) Graham's law; (b) Avogadro's principle; (c) Gay-Lussac's law of combining volumes; (d) Dalton's principle. \_\_\_\_\_ 2
3. The value of  $R$ , the ideal gas constant, can be calculated from measured values of a gas's pressure, volume, temperature, and (a) molar amount; (b) chemical formula; (c) rate of diffusion; (d) density. \_\_\_\_\_ 3
4. All of the following equations are statements of the ideal gas law except (a)  $P = nRT/V$ ; (b)  $(PV)/T = nR$ ; (c)  $P/n = (RT)/V$ ; (d)  $R = (PV)/(nT)$ . \_\_\_\_\_ 4
5. To use the ideal gas law to determine the molar mass of a gas (a) the mass of a molar volume of the gas must be determined; (b) the mass of any known volume of the gas may be used; (c) a volume of less than 22.4 may not be used; (d) the volume measurement must be made at STP. \_\_\_\_\_ 5
6. If  $n$  and  $T$  are constant, the ideal gas law reduces to (a) Charles' law; (b) Boyle's law; (c) Avogadro's principle; (d) zero. \_\_\_\_\_ 6
7. If  $n$  and  $P$  are constant, the ideal gas law reduces to (a) Charles' law; (b) Boyle's law; (c) Avogadro's principle; (d) zero. \_\_\_\_\_ 7
8. If  $P$  and  $T$  are constant, the ideal gas law reduces to (a) Charles' law; (b) Boyle's law; (c) Avogadro's principle; (d) zero. \_\_\_\_\_ 8

**DIRECTIONS:** Write the answer to questions 9–15 on the line to the right, and show your work in the space provided.

9. Calculate the volume occupied by 12.0 g of carbon dioxide ( $\text{CO}_2$ , 44 g/mol) at  $20.0^\circ\text{C}$  and 740 mm Hg. \_\_\_\_\_ 9
10. What is the mass of chlorine gas ( $\text{Cl}_2$ , 70.9 g/mol) contained in a 5.00 L flask at  $27^\circ\text{C}$  and 720 mm Hg? \_\_\_\_\_ 10
11. Calculate the approximate volume of a 0.60 mol sample of gas at  $15^\circ\text{C}$  and a pressure of 1.1 atm. \_\_\_\_\_ 11
12. What is the approximate pressure exerted by 1.2 mol of a gas with a temperature of  $20^\circ\text{C}$  and a volume of 9.5 L? \_\_\_\_\_ 12
13. A gas sample, mass 0.467 g, is collected at  $20^\circ\text{C}$  and 732.5 mm Hg. The volume is 200. mL. What is the molar mass of the gas? \_\_\_\_\_ 13
14. A gas sample, mass 0.686 g, is collected at  $20^\circ\text{C}$  and 722.5 mm Hg. Its volume is 350 mL. What is the molar mass of the gas? \_\_\_\_\_ 14
15. A gas sample, mass 2.50 g, is collected at  $20.0^\circ\text{C}$  and 732.5 mm Hg. Its volume is 1.28 L. What is the molar mass of the gas? \_\_\_\_\_ 15

# IDEAL GAS LAW

Name \_\_\_\_\_

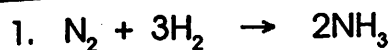
Use the Ideal Gas Law below to solve the following problems.

$$PV = nRT \text{ where } P = \text{pressure in atmospheres}$$
$$V = \text{volume in liters}$$
$$n = \text{number of moles of gas}$$
$$R = \text{Universal Gas Constant}$$
$$0.0821 \text{ L} \cdot \text{atm/mol} \cdot \text{K}$$
$$T = \text{Kelvin temperature}$$

1. How many moles of oxygen will occupy a volume of 2.5 liters at 1.2 atm and 25° C?  
\_\_\_\_\_
2. What volume will 2.0 moles of nitrogen occupy at 720 torr and 20° C?  
\_\_\_\_\_
3. What pressure will be exerted by 25 g of CO<sub>2</sub> at a temperature of 25° C and a volume of 500 mL? \_\_\_\_\_
4. At what temperature will 5.00 g of Cl<sub>2</sub> exert a pressure of 900. torr at a volume of 750 mL? \_\_\_\_\_
5. What is the density of NH<sub>3</sub> at 800 torr and 25° C? \_\_\_\_\_
6. If the density of a gas is 1.2 g/L at 745. torr and 20° C, what is its molecular mass?  
\_\_\_\_\_
7. How many moles of nitrogen gas will occupy a volume of 347 mL at 6680 torr and 27° C? \_\_\_\_\_
8. What volume will 454 grams (1 lb) of hydrogen occupy at 1.05 atm and 25° C?  
\_\_\_\_\_
9. Find the number of grams of CO<sub>2</sub> that exert a pressure of 785 torrs at a volume of 32.5 L and a temperature of 32° C. \_\_\_\_\_
10. An elemental gas has a mass of 10.3 g. If the volume is 58.4 L and the pressure is 758 torrs at a temperature of 2.5° C, what is the gas? \_\_\_\_\_

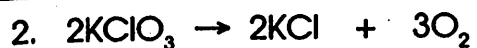
# STOICHIOMETRY: MIXED PROBLEMS

Name \_\_\_\_\_



What volume of  $\text{NH}_3$  at STP is produced if 25.0 g of  $\text{N}_2$  is reacted with an excess of  $\text{H}_2$ ?

\_\_\_\_\_



If 5.0 g of  $\text{KClO}_3$  is decomposed, what volume of  $\text{O}_2$  is produced at STP?

\_\_\_\_\_

3. How many grams of  $\text{KCl}$  are produced in Problem 2?

\_\_\_\_\_



What volume of hydrogen at STP is produced when 2.5 g of zinc react with an excess of hydrochloric acid?

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How many liters of water are produced if 2.0 g of sodium sulfate are produced in the above reaction at 745 torr and 25.0°C?

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If 10.0 g of aluminum chloride are decomposed, how many liters of  $\text{Cl}_2$  are produced at 1.23 atm and 12.0°C?

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## Gas Stoichiometry Practice

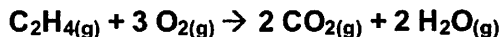
*For all of these problems, assume that the reactions are being performed at a pressure of 1.0 atm and a temperature of 298 K.*

- 1) Calcium carbonate decomposes at high temperatures to form carbon dioxide and calcium oxide:



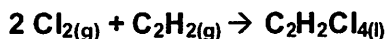
How many grams of calcium carbonate will I need to form 3.45 liters of carbon dioxide?

- 2) Ethylene burns in oxygen to form carbon dioxide and water vapor:



How many liters of water can be formed if 1.25 liters of ethylene are consumed in this reaction?

- 3) When chlorine is added to acetylene, 1,1,2,2-tetrachloroethane is formed:



How many liters of chlorine will be needed to make 75.0 grams of  $\text{C}_2\text{H}_2\text{Cl}_4$ ?

3. What volume of carbon dioxide,  $\text{CO}_2$ , at STP can be produced when 8.0 grams of oxygen,  $\text{O}_2$ , react with an excess of ethane,  $\text{C}_2\text{H}_6$ ?

4. a. How many grams of carbon dioxide,  $\text{CO}_2$ , are formed if 96.0 g of oxygen,  $\text{O}_2$ , react with 12.2 g of ethylene,  $\text{C}_2\text{H}_4$ , to form carbon dioxide and water? Assume STP. Which reactant is the limiting one?

b. How many grams of  $\text{CO}_2$  are produced when 20.0 g of  $\text{O}_2$  react with 31.0 g of ethylene? Assume STP. Which reactant is the limiting one?

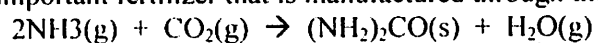
### More Gas Stoichiometry

What volume of carbon dioxide is produced if 48.2 g aluminum carbonate decomposes at 93.3 kPa and 23.0°C?

The combustion of 12.4 L of ethyne ( $C_2H_2$ ) at STP, will produce what volume of water at 12.3°C and 732 torr?

In the reaction of 14.7 g of aluminum chloride with 21.4 ml of hydrogen iodide gas, what volume of hydrogen gas will be produced if the reaction takes place at 850. torr and 19.2°C?

Urea,  $(NH_2)_2CO$ , is an important fertilizer that is manufactured through the following reaction:



What volume of ammonia at STP will be needed to produce  $8.50 \times 10^1$  kg of urea if there is an 89.5% yield in the process?

# GRAHAM'S LAW OF EFFUSION

Name \_\_\_\_\_

Graham's Law says that a gas will effuse at a rate that is inversely proportional to the square root of its molecular mass, MM. Expressed mathematically:

$$\frac{\text{rate}_1}{\text{rate}_2} = \sqrt{\frac{\text{MM}_2}{\text{MM}_1}}$$

Solve the following problems.

1. Under the same conditions of temperature and pressure, how many times faster will hydrogen effuse compared to carbon dioxide?

\_\_\_\_\_

2. If the carbon dioxide in Problem 1 takes 32 sec to effuse, how long will the hydrogen take?

\_\_\_\_\_

3. What is the relative rate of diffusion of  $\text{NH}_3$  compared to He? Does  $\text{NH}_3$  effuse faster or slower than He?

\_\_\_\_\_

4. If the He in Problem 3 takes 20 sec to effuse, how long will  $\text{NH}_3$  take?

\_\_\_\_\_

5. An unknown gas diffuses 0.25 times as fast as He. What is the molecular mass of the unknown gas?

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## Ch 11 Test Review

1. Assuming STP, calculate the masses of each of the following volumes of gases.
  - a. 22.4L of  $\text{NH}_3$
  - b. 12.1L of  $\text{H}_2\text{O}$
  - c. 678 ml of  $\text{CO}_2$
2. One liter of a gas has a mass of 0.716g at STP. What is its molar mass?
3. What is the density of  $\text{H}_2\text{S}$  at 723 torr and  $55^\circ\text{C}$ ?
4. An amount of chlorine gas occupies a volume of 50.0L at  $27^\circ\text{C}$  and 721mm Hg. What is the mass of the chlorine?
5. If 15.1g of copper(II) sulfate pentahydrate is heated, what volume of water vapor is produced at STP?
6. The decomposition of potassium chlorate at 730 mm Hg and  $25^\circ\text{C}$  produces 143 ml of  $\text{O}_2$ . What mass of potassium chlorate was used?
7. If 30.2L of hydrogen are combined with 24.3g of oxygen how much water vapor is produced at STP?